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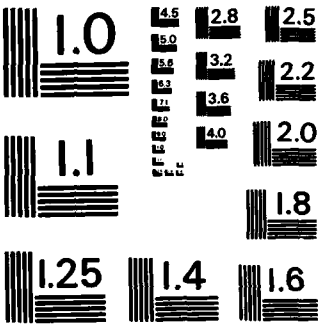

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FORECAST AIDS FOR PREDICTING TROPICAL CYCLONE ASSOCIATED GUSTS AND SUSTAINED WINDS FOR CUBI POINT, PHILIPPINES

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Forecast aids are provided for predicting wind conditions at a station when a tropical cyclone passes within 360 n mi. The forecast aids were produced by analyzing a data set comprising the ratios of station wind values to tropical cyclone center wind values. Ratio values were then assigned to the position of the cyclone center. The 360 n mi radius circle about the station was divided into 71 equal area segments and the values of the mean and maximum ratio within each segment were subjectively analyzed to produce the forecast aids.

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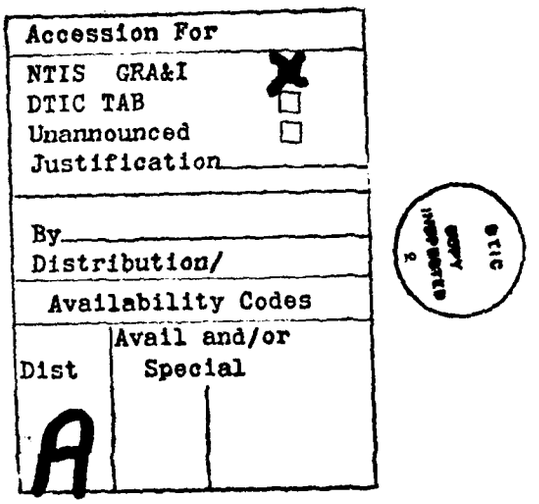
CONTENTS



1. INTRODUCTION

Forecasting wind conditions at a station during the passage of a tropical cyclone is a critical problem for operational environmentalists. The Air Force has produced forecast aids for predicting mean and maximum peak gusts, for several western Pacific Air Force Bases (Pettett, 1980), for periods when a typhoon was within 360 n mi of a base. The need for similar forecast aids for Navy sites was recognized and the Naval Environmetnal Prediction Research Facility (NEPRF), Monterey, California was requested to produce the aids. Science Applications, Inc., under contract to NEPRF has conducted the research and development involved in producing forecast aid reports for Yokosuka, Japan and Cubi Point, Phlippines.

2. PRODUCTION OF FORECAST AIDS

The forecast aids are based on a data period extending from the establishment of a U.S. Navy weather observation program at the stations of interest through 1979. This is a 27 year period for Yokosuka (1953-1979) and 25 years for Cubi Point (1955-1979). Best track data for the tropical cyclones were extracted from Joint Typhoon Warning Center (JTWC) records for the periods when a tropical cyclone was within 360 n mi of the station of interest. Aviation hourly observations at three-hour intervals, obtained from the Naitonal Climatic Center (NCC), Asheville, NC, were extracted for the periods identified as having a tropical cyclone within 360 n mi of the station.[1] The best track

[1]Aviation hourly observations are archived at NCC for the local times corresponding to 00,03,06,09,12,15,18,21 GMT only.

and weather observations were then merged into a new data base. From this data, ratios of storm center winds to station reported sustained winds were determined and assigned to the storm center position. The 360 n mi radius circle was divided into 71 equal areas (Fig.1).

The ratios identified with each area were summarized and maximum and mean gust ratios and standard deviations were determined. The number of ratios per area (sample size) and cumulative frequency distribution of the ratios were also computed. Computer plots of the gust ratios, sample size and area number values were generated. The gust ratio plots were then subjectively analyzed taking into consideration such factors as sample size for the mean gusts and cumulative distribution frequency for the maximum gusts.

The analyses of the data are presented as isolines which represent the climatological mean or maximum gust to be expected at the station as a percentage of the tropical cyclone center wind. The data base is separated into two classifications of cyclones, i.e., typhoons and lesser tropical cyclones. The classification is based on the cyclone center wind speed at the time of the station wind observation. A set of analyses is provided for each cyclone classification. In addition, a table containing all the data necessary to produce figures 1 through 5 is provided. The data in the table will assist local reanalysis if required.

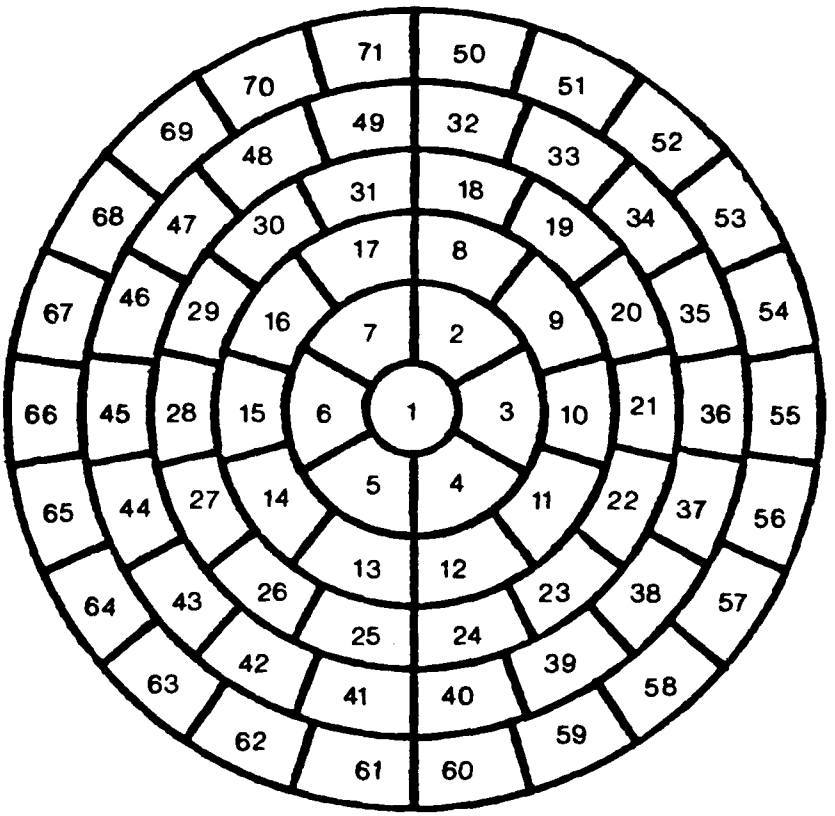


Figure 1. A 360 n mi radius circle divided into 71 equal area (5734.5 n mi^2) segments which can be centered on the station of interest. The circle is comprised of an inner circle and five surrounding rings. The radial thickness of each ring is approximately 60 n mi, but is not a constant. The segments are numbered from the inner circle and spiral outward.

3. USE OF THE FORECAST AIDS

The forecast aids can be utilized as follows:

1) Locate the actual or forecast tropical cyclone center position on the appropriate forecast aid analysis; 2) determine the maximum gust ratio value by interpolating between the contours; and 3) apply this ratio (percentage to the cyclone center wind value to obtain the maximum or mean gust values to be used as a forecast aid in making the wind forecast. For example, if a tropical cyclone has center winds of 100 kt and a ratio of .65 was determined above, then 65% of the center wind gives forecast gusts to 65 kt for the station.

Sustained one-minute maximum and average wind values can be found by applying a factor of 2/3 to the gust values. This factor is the inverse of the 1.5 to 1 ratio of gusts to sustained winds that was used in the Air Force reports and verified as follows. A study of the wind observations recorded at Cubi Point (1953-1979) and Yokosuka (1955-1979) was made as part of the development of the methodology used in producing these forecast aids. That data set included the NCC tape archived data, hand augmented with gust data. A uniform ratio of gust to sustained wind speed of 1.5:1 was found over various speed ranges and at both stations. The data set included all station observations (Cubi Point 3449 and Yokosuka 2114) with sustained winds of 10 knots or more when a tropical cyclone was within 360 n mi of the station. This ratio was found to be reasonable for all tropical cyclone intensity classifications and station wind conditions.

Forecasters should recognize that all of the gust information is based on the archived sustained winds (aviation observations at three hour intervals from NCC) multiplied by 1.5. In determining this multiplier, local effects as they relate to various wind directions were only indirectly taken into account. That is, the ratios assigned to each area relate only to storms centered in that area. The storm center location relative to the station location strongly influences the station wind velocity. Therefore, some degree of local effects are inherent in the analyzed ratio patterns.

Table 1 summarizes the data used in producing the forecast aids. The data in Table 1 is sufficient to reproduce figures 1 through 5 should local reproduction or modifications be desired. The ratio values in Table 1 represent the relationship of station sustained winds to tropical cyclone center winds. To derive the forecast aids for gust values the 1.5 multiplier must be applied.

Figures 2 through 5 are the forecast aid analyses. The contours are labelled as percentages which were derived from the ratios of station winds to tropical cyclone center winds. Note that the center contours on all but figure 2 are less than 100 percent. For example, the maximum gust aid for typhoon strength tropical cyclones (Fig.4) shows only a 70 percent contour around the station. Table 1, segment 1 for tropical cyclones of 64 kt or greater shows 16 cases of typhoon strength centers being located within the area of segment 1. The maximum sustained wind to typhoon center wind ratio that occurred during the 16 cases is .494 to 1. Segment 3, located east of the station (Fig.1), shows

14 cases of typhoon strength centers with a maximum ratio of .521 to 1. Applying the 1.5 multiplier to the ratios of segments 1 and 3 results in the data that supports the 70 percent contour.

The interpretation of figure 4 is that Cubi Point has not experienced winds at the official observation point of as great an intensity as the official typhoon center winds during typhoon passages. While these findings are based on a reasonable sample size, caution should be used in applying these results when a typhoon center is expected to pass over or very near the station.

Inconsistent gust values will be obtained from the aids when a tropical cylone center wind change results in a change of cyclone classification and therefore a change of forecast aid. For example, use of figure 2 for a tropical storm forecast to pass over the station with 60 kt center winds would indicate a maximum gust of 72 kt. A change in center wind to 65 kt and the use of figure 4 indicates 46 kt maximum gusts. An intermediate value is the likely best guidance in such cases.

REFERENCE

Pettett, J.E., 1980: Prediction of Typhoon-Induced Peak Winds at Four Pacific Stations. 1WW/TN-80/001.

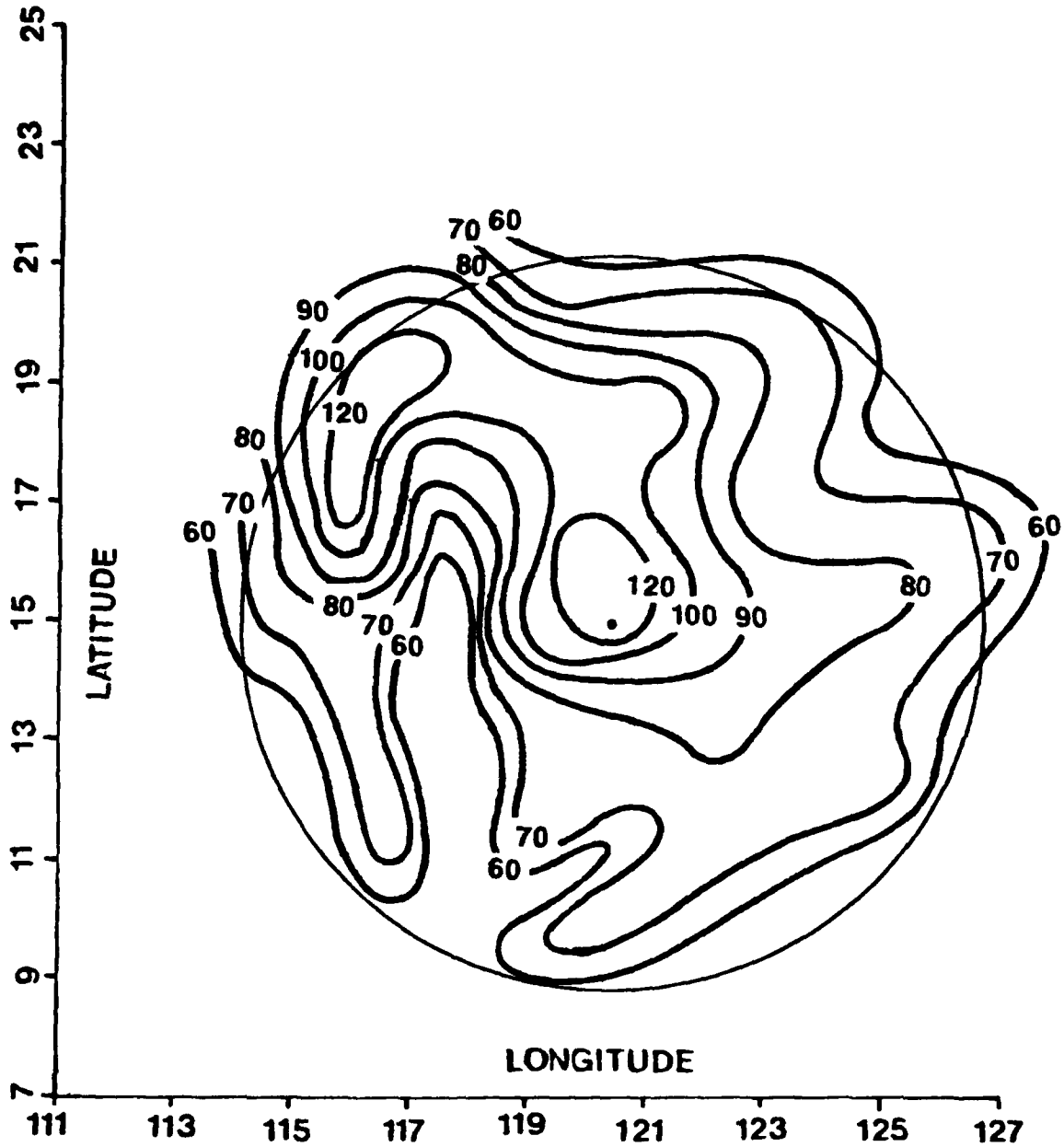


Figure 2. Maximum Gust Ratios (labelled as percentage) for Cubi Point when a tropical cyclone of less than typhoon strength (<64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the maximum gust expected with the given center position and wind speed. Multiply the maximum gust speed by 0.67 to find the maximum one-minute average sustained wind speed.

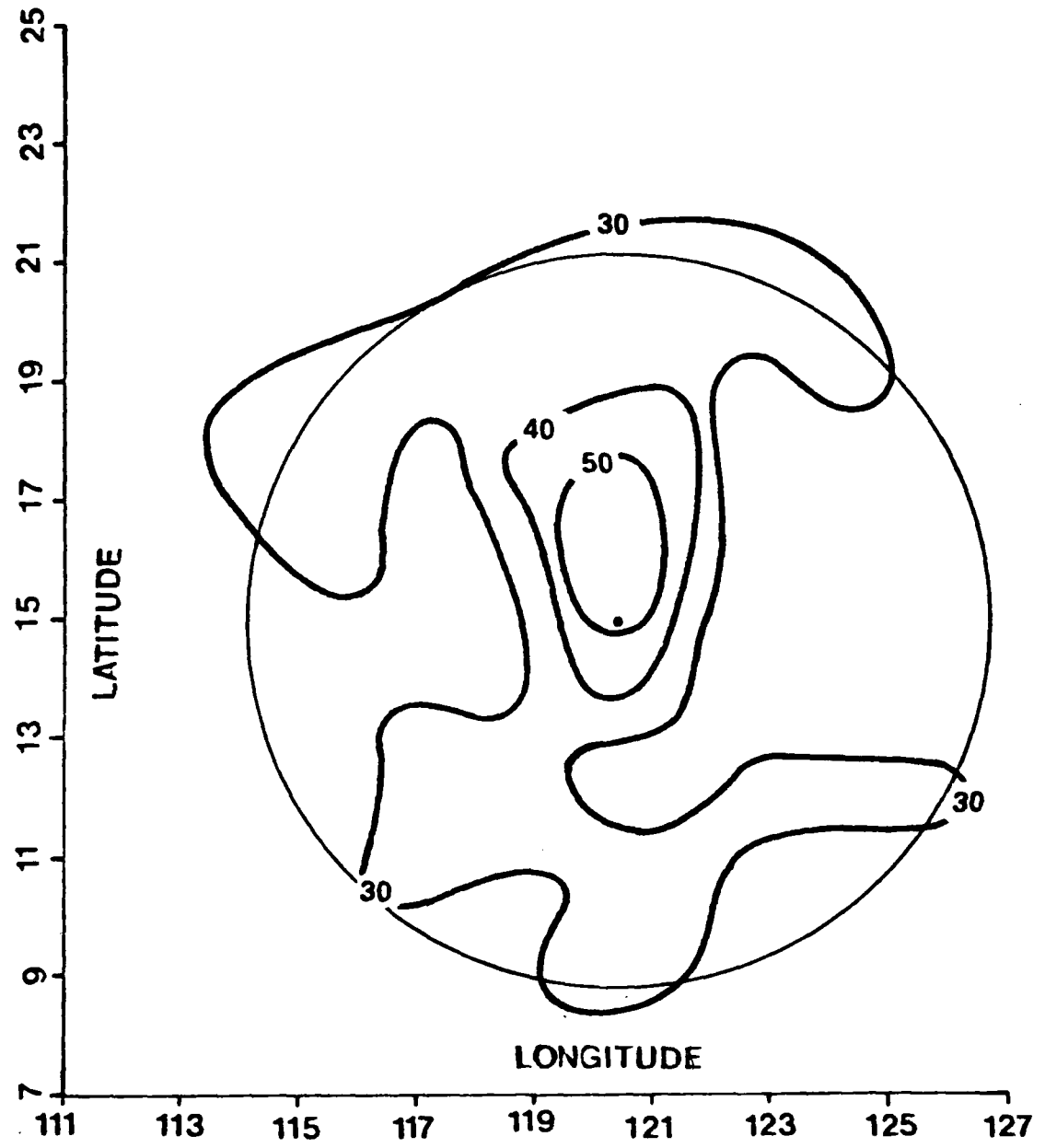


Figure 3. Mean Gust Ratios (labelled as percentage) for Cubi Point when a tropical cyclone of less than typhoon strength (<64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the mean gust expected with the given center position and wind speed. Multiply the mean gust speed by 0.67 to find the mean one-minute average sustained wind speed.

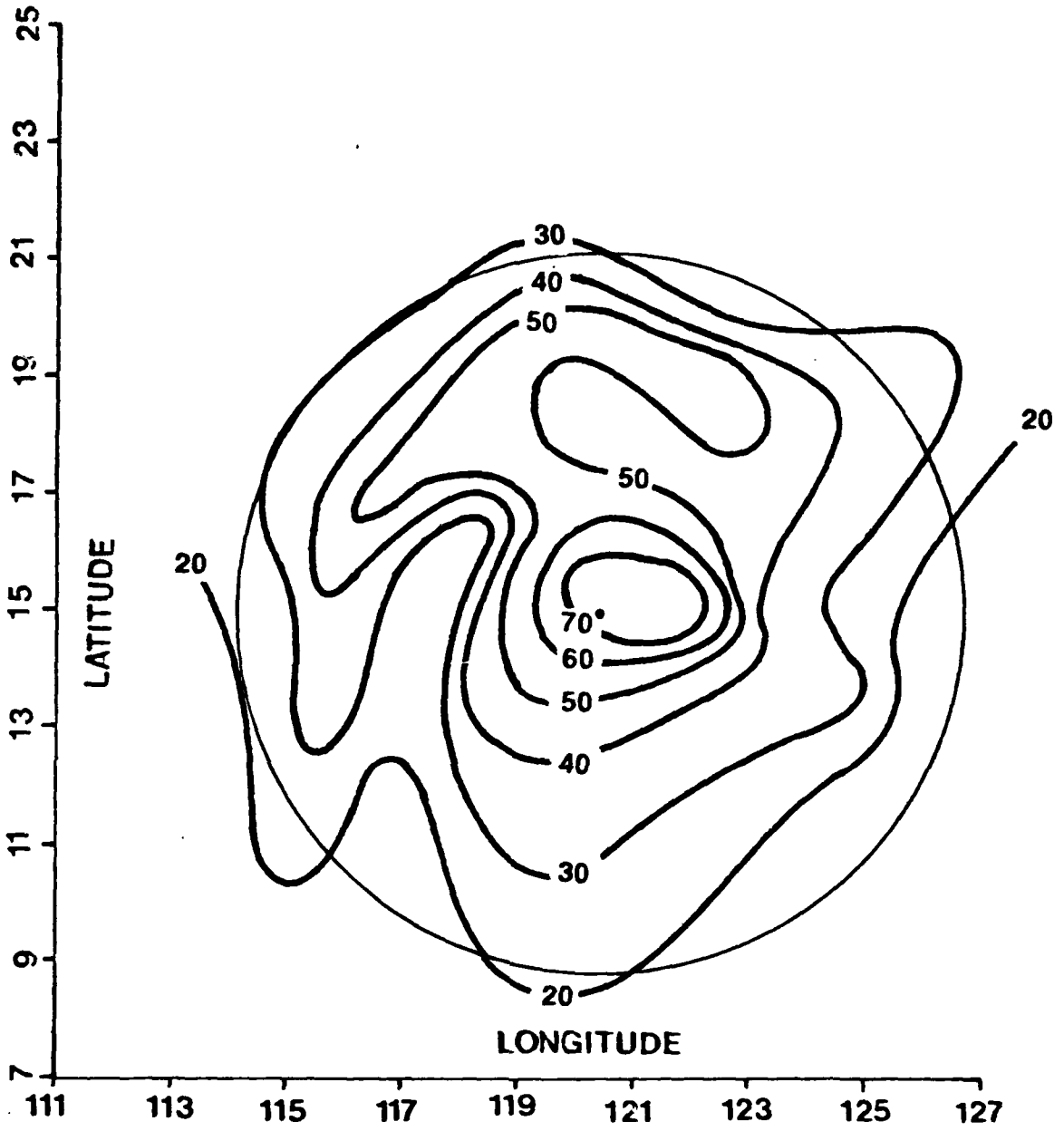


Figure 4. Maximum Gust Ratios (labelled as percentage) for Cubi Point when a tropical cyclone of typhoon strength (≥64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the maximum gust expected with the given center position and wind speed. Multiply the maximum gust speed by 0.67 to find the maximum one-minute average sustained wind speed.

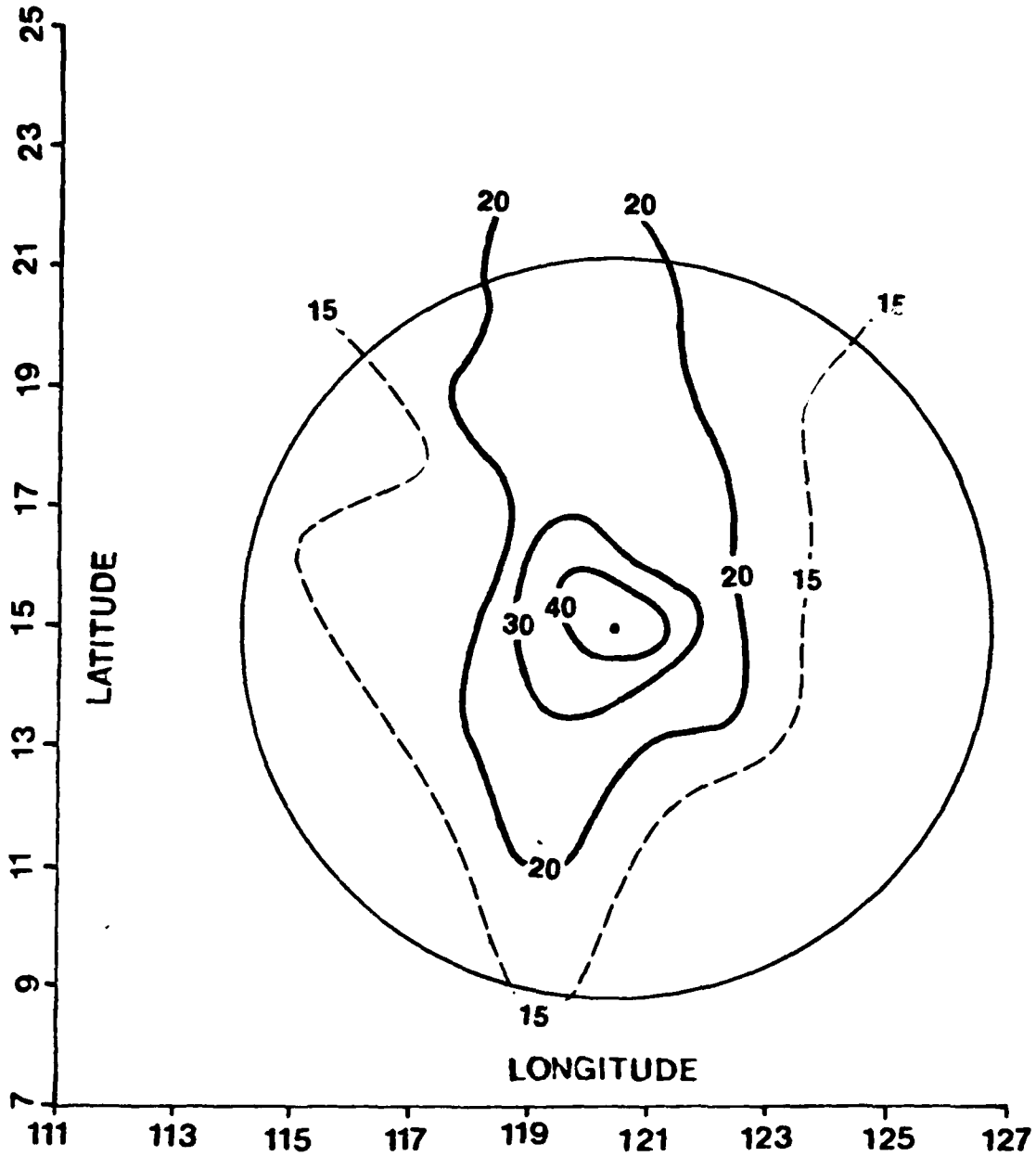


Figure 5. Mean Gust Ratios (labelled as percentage) for Cubi Point when a tropical cyclone of typhoon strength ($\geq$64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the mean gust expected with the given center position and wind speed. Multiply the mean gust speed by 0.67 to find the mean one-minute average sustained wind speed.

Table 1. A listing of the data used in producing figures 1 through 5, and other general information. Table contents by column are: segment number, latitude and longitude of segment center, maximum ratio, mean ratio, standard deviation of ratios, number of ratios (sample size), and cumulative frequency distribution expressed as the percentage of ratios occurring between 0.0 and the maximum ratio or 1.0 in 0.1 increments.

Tropical cyclones less than 64 kts

CENTER POINT							
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
1	14.8	120.3	1.045	.364	.249	40	15 28 53 63 75 85 90 93 95 100
RING NUMBER 1							
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
2	16.0	121.3	.857	.338	.258	45	22 42 53 67 78 80 82 96 100
3	14.8	121.8	.750	.184	.144	43	40 70 80 93 98 98 98 100
4	13.6	121.0	.532	.254	.141	36	19 36 67 91 97 100
5	13.6	119.6	.789	.257	.120	42	2 33 69 95 98 98 98 100
6	14.8	118.8	.800	.225	.147	53	17 55 81 91 92 98 98 100
7	16.0	119.6	.914	.353	.202	48	6 23 48 67 75 90 96 96 98 100
RING NUMBER 2							
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
8	17.1	121.1	.581	.303	.127	27	7 22 48 78 93 100
9	16.2	122.4	.480	.195	.129	25	36 64 80 92 100
10	14.8	122.8	.360	.146	.095	25	44 76 88 100
11	13.4	122.4	.563	.182	.137	36	39 69 72 92 97 100
12	12.5	121.1	.600	.189	.126	21	24 67 90 95 95 100
13	12.5	119.5	.500	.193	.092	48	8 65 90 96 100
14	13.4	118.2	.550	.194	.098	33	21 61 94 97 97 100
15	14.8	117.8	.333	.184	.068	34	12 68 94 100
16	16.2	118.2	.560	.216	.139	41	24 63 71 90 93 100
17	17.1	119.5	.675	.342	.160	42	12 17 40 74 86 93 100
RING NUMBER 3							
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
18	18.2	121.1	.900	.301	.196	52	19 35 67 83 88 90 92 96 100
19	17.5	122.5	.458	.162	.092	24	33 75 92 96 100
20	16.3	123.5	.489	.184	.105	36	36 58 89 97 100
21	14.8	123.9	.567	.196	.111	47	21 66 89 96 98 100
22	13.3	123.5	.300	.116	.066	24	42 92 100
23	12.1	122.5	1.000	.266	.223	20	25 55 75 85 85 95 95 95 95 100
24	11.4	121.1	.400	.185	.107	23	22 70 87 100
25	11.4	119.5	.500	.272	.161	18	17 56 56 72 100
26	12.1	118.1	.385	.214	.100	9	11 56 78 100
27	13.3	117.1	.900	.213	.187	30	13 67 93 93 93 93 93 93 100
28	14.8	116.7	.433	.186	.101	50	25 61 86 96 100
29	16.3	117.1	.380	.187	.106	22	27 59 82 100
30	17.5	118.1	.640	.263	.139	45	7 40 64 84 96 98 100
31	18.2	119.5	.667	.269	.174	54	19 44 63 81 87 93 100

RING NUMBER 4

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
32	19.2	121.1	.600	.234	.169	39	26 51 74 87 87 100
33	18.7	122.6	.526	.181	.114	24	17 75 83 96 96 100
34	17.7	123.8	.467	.190	.109	32	28 59 84 94 100
35	16.3	124.7	.560	.136	.113	45	47 87 89 93 98 100
36	14.8	124.9	.667	.151	.130	49	41 82 94 96 96 96 100
37	13.3	124.7	.550	.142	.119	22	45 77 91 95 95 100
38	11.9	123.8	.833	.194	.163	23	26 78 91 91 96 96 96 96 100
39	10.9	122.6	.476	.186	.130	24	33 71 79 92 100
40	10.4	121.1	.483	.232	.134	19	21 58 74 84 100
41	10.4	119.5	.333	.185	.091	7	14 57 86 100
42	10.9	118.0	.480	.237	.134	10	20 50 80 80 100
43	11.9	116.8	.480	.211	.127	8	25 63 88 88 100
44	13.3	115.9	.450	.195	.108	27	22 59 85 93 100
45	14.8	115.7	.467	.187	.107	41	27 61 83 98 100
46	16.3	115.9	1.111	.271	.225	51	20 49 73 80 88 88 94 96 96 100
47	17.7	116.8	.524	.192	.107	44	27 55 84 98 98 100
48	18.7	118.0	.720	.213	.143	50	22 60 76 94 96 98 98 100
49	19.2	119.5	.658	.224	.155	45	31 53 71 91 91 98 100

RING NUMBER 5

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
50	20.2	121.1	.500	.223	.135	16	19 50 75 94 100
51	19.8	122.7	.500	.216	.165	14	43 57 64 86 100
52	18.9	124.0	.500	.256	.153	17	18 47 71 76 100
53	17.8	125.1	.800	.187	.143	32	34 69 88 97 97 97 97 100
54	16.3	125.7	.500	.144	.104	27	41 81 93 96 100
55	14.8	126.0	.786	.215	.202	23	35 70 87 87 87 91 91 100
56	13.3	125.7	.417	.149	.080	26	31 85 92 96 100
57	11.8	125.1	.480	.231	.118	17	18 59 82 88 100
58	10.7	124.0	.342	.176	.092	17	35 59 94 100
59	9.8	122.7	.320	.168	.077	13	23 69 92 100
60	9.4	121.1	.560	.201	.148	8	13 63 88 88 88 100
61	9.4	119.5	.560	.296	.145	9	0 33 56 78 89 100
62	9.8	117.9	.203	.146	.041	7	29 86 100
63	10.7	116.6	.480	.249	.154	10	20 50 50 80 100
64	11.8	115.5	.081	.081	.000	1	100
65	13.3	114.9	.350	.172	.080	19	21 74 89 100
66	14.8	114.6	.519	.164	.123	49	33 78 86 94 98 100
67	16.3	114.9	.600	.235	.161	35	29 46 74 83 91 100
68	17.8	115.5	.800	.223	.208	33	36 67 76 79 91 94 94 100
69	18.9	116.6	1.120	.253	.254	46	26 61 80 85 87 89 91 93 93 100
70	19.8	117.9	.667	.232	.156	54	22 52 70 85 93 98 100
71	20.2	119.5	.438	.237	.125	16	19 38 69 94 100

Tropical cyclones of 64 kt or greater

SEG	CENTER POINT LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
1	14.8	120.3	.494	.265	.146	16	13 44 63 75 100

RING NUMBER 1

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
2	16.0	121.0	.448	.167	.123	19	37 74 84 89 100
3	14.8	121.8	.521	.262	.131	14	14 36 57 79 93 100
4	13.6	121.0	.308	.180	.074	9	0 67 78 100
5	13.6	119.6	.369	.243	.089	8	13 25 63 100
6	14.8	118.8	.338	.200	.080	15	20 53 87 100
7	16.0	119.6	.353	.249	.093	10	0 30 50 100

RING NUMBER 2

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
8	17.1	121.1	.314	.149	.092	15	33 73 93 100
9	16.2	122.4	.261	.136	.060	20	30 90 100
10	14.8	122.8	.267	.125	.069	28	36 89 100
11	13.4	122.4	.241	.138	.053	15	27 93 100
12	12.5	121.1	.194	.109	.050	13	38 100
13	12.5	119.5	.269	.123	.056	13	54 92 100
14	13.4	118.2	.271	.143	.059	7	14 86 100
15	14.8	117.8	.200	.110	.059	14	43 100
16	16.2	118.2	.185	.102	.041	12	42 100
17	17.1	119.5	.400	.152	.110	16	50 75 88 100

RING NUMBER 3

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
18	18.2	121.1	.313	.156	.073	26	23 69 96 100
19	17.5	122.5	.330	.132	.071	41	44 85 95 100
20	16.3	123.5	.277	.120	.067	26	42 81 100
21	14.8	123.9	.161	.067	.040	41	80 100
22	13.3	123.5	.253	.103	.062	19	53 89 100
23	12.1	122.5	.192	.091	.054	13	77 100
24	11.4	121.1	.076	.076	.000	1	100
25	11.4	119.5	.200	.142	.024	9	0 100
26	12.1	118.1	.165	.091	.038	6	67 100
27	13.3	117.1	.152	.109	.029	8	50 100
28	14.8	116.7	.165	.100	.055	4	50 100
29	16.3	117.1	.242	.068	.057	19	79 95 100
30	17.5	118.1	.359	.124	.082	16	50 88 94 100
31	18.2	119.5	.301	.178	.086	25	16 64 96 100

RING NUMBER 4

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST'N
32	19.2	121.1	.341	.148	.097	27	37 74 93 100
33	18.7	122.6	.413	.116	.085	30	63 80 97 97 100
34	17.7	123.8	.275	.088	.056	50	72 96 100
35	16.3	124.7	.198	.075	.054	41	73 100
36	14.8	124.9	.169	.073	.042	29	69 100
37	13.3	124.7	.210	.056	.048	23	87 96 100
38	11.9	123.8	.175	.084	.047	15	67 100
39	10.9	122.6	.200	.177	.023	2	0 100
40	10.4	121.1	.154	.137	.017	2	0 100
41	10.4	119.5	.250	.173	.052	8	0 63 100
42	10.9	118.0	.157	.113	.038	11	45 100
43	11.9	116.8	.100	.076	.019	7	100
44	13.3	115.9	.185	.081	.054	8	63 100
45	14.8	115.7	.253	.118	.067	17	47 82 100
46	16.3	115.9	.435	.141	.121	17	47 76 88 88 100
47	17.7	116.8	.282	.092	.071	18	72 89 100
48	18.7	118.0	.373	.155	.074	34	21 76 97 100
49	19.2	119.5	.329	.180	.082	37	16 51 89 100

RING NUMBER 5

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST'N
50	20.2	121.1	.254	.153	.071	24	25 67 100
51	19.8	122.7	.195	.098	.051	33	55 100
52	18.9	124.0	.261	.099	.054	18	56 94 100
53	17.8	125.1	.215	.067	.054	40	75 98 100
54	16.3	125.7	.198	.076	.048	40	68 100
55	14.8	126.0	.120	.054	.028	17	94 100
56	13.3	125.7	.123	.051	.032	25	92 100
57	11.8	125.1	.100	.056	.023	11	100
58	10.7	124.0	.192	.095	.053	5	60 100
59	9.8	122.7				0	
60	9.4	121.1				0	
61	9.4	119.5	.169	.162	.008	2	0 100
62	9.8	117.9	.092	.068	.024	2	100
63	10.7	116.6	.108	.088	.016	3	67 100
64	11.8	115.5	.200	.093	.046	13	62 100
65	13.3	114.9	.099	.059	.039	4	100
66	14.8	114.6	.126	.076	.033	14	64 100
67	16.3	114.9	.261	.097	.059	18	61 94 100
68	17.8	115.5	.115	.076	.028	11	73 100
69	18.9	116.6	.215	.098	.059	31	58 97 100
70	19.8	117.9	.194	.110	.047	26	46 100
71	20.2	119.5	.338	.169	.085	34	29 71 95 100

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